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ABSTRACT

Biotechnology is the name given to a group of technologies that use organisms to make or modify various products or to provide services. Emphasis by companies in the biotechnology field has been on research; therefore, they have preferred to employ four-year college graduates or graduate-degreed persons. Now, however, emphasis is shifting from research to production, and a new type of worker may be needed. A two-year training curriculum for biotechnicians is proposed in this paper. It is made up of six quarters and emphasizes biology and chemistry courses. Internships also are suggested. If schools cannot implement a two-year curriculum, they can add courses to the existing chemistry curriculum or to other programs until local needs justify a full biotechnician program. (KC)

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A MODEL CURRICULUM FOR TRAINING BIOTECHNICIANS

Presentation to

Technical Education Division
American Vocational Association

Dallas, Texas

December 7, 1986

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by

Ron Thomson
Center for Occupational Research and Development
Waco, Texas

INTRODUCTION

In early 1986, the Center for Occupational Research and Development (CORD) completed a study that assessed the projected need for biotechnicians in the United States through 1995 and identified a possible structure for a biotechnician curriculum. This research was sponsored by community colleges in The Mid-America Group, by Texas State Technical Institute, the Georgia Board of Postsecondary Vocational Education, and the Colorado State Board of Community Colleges and Occupational Education.

CORD specializes in assessing training needs for emerging technologies, in designing and developing technical curricula, and in working with schools to help them better provide for the changing needs of industry.

BACKGROUND

Biotechnology is the name given to a group of technologies that uses organisms (or natural or synthetic parts thereof) to make or modify various products or to provide services. By that definition, biotechnology is not new: human beings have used yeasts in baking bread and making alcoholic beverages for hundreds of years. The current push to find new applications for biotechnology stems from advances in electronic/electromechanical areas such as scanning electron microscopes, biosensors, computers, and other highly sensitive and specialized instrumentation. As a result of these advances, scientists are now able to alter an organism's genetic code to produce a wide assortment of substances that are beneficial to humanity.

Most people think of high technology in terms of sophisticated machines such as computers and robots. The products of the biotech revolution, however, are often microscopic organisms--bacteria, viruses and yeasts. The organisms have been selected, modified in many cases, bred and used to produce an assortment of useful products such as food, drugs, and fuels and to perform tasks such as desulfuring coal, cleaning up hazardous wastes and assisting in the recovery of oil from spent

wells. Four major areas for applications of biotechnology stand out: human health, agriculture and animal health, energy and environment, and food.

Because biotechnology encompasses a wide range of processes and applications, the technicians who work in the field must have a broad background. They must be trained in practical applications of biology, chemistry, instrumentation and computer operation, and they must possess well-developed skills in math and communication. These technicians usually work in one specialty area such as recombinant DNA, cell/tissue culture, or fermentation technology.

NEED FOR TECHNICIANS

How many biotechnicians are needed? To answer this question, CORD surveyed 242 biotech companies; 36% percent of those surveyed provided usable responses. When the responses were interpolated for all 242 companies, the number of biotechnicians needed by 1995 was calculated to be 12,538. Projections for the years 1987, 1990 and 1995 indicate a growth pattern that follows an almost straight line. This means that roughly 1,250 new biotechnicians will be needed each year.

Where do biotech companies get their technicians? Currently, the companies hire technicians with B.S. and M.S. degrees 75% of the time. Since most companies have been more involved in research and development than in production up to this point in time, technicians with four-year degrees have been appropriate. Furthermore, the labor pool holds a glut of people with B.S. degrees in biology and chemistry, so companies hire them because they are readily available.

Many biotech companies now have products that are almost ready to go into production. Few of these companies, however, realize that production may require technicians who are different from the technicians who work in research and development. Yet, this has been the case in other high-tech areas, and there is no apparent reason why biotechnology should be any different.

By the time a product reaches production, procedures are established and work becomes relatively routine. Also, production work is often shift work. For such reasons, the work of a production technician usually does not bring career satisfaction to individuals with B.S. and M.S. degrees. Still, however, all production processes must be monitored and controlled by individuals who are intelligent, competent, and well-trained. This is where technicians from two-year degree programs become important.

MODEL CURRICULUM

Two-year schools can respond to needs in the biotechnology industry in a number of ways. They can implement full two-year degree programs in biotechnology, deliver specific courses for retraining or upgrading existing technicians, provide facilities for industry to conduct their own training, provide career development guidance, and last but not least, provide information about biotechnology to the general public to help overcome negative publicity and irrational fears. Industry representatives strongly emphasize that schools should work closely with local biotech companies when they start seeking roles in biotechnology, for local needs can vary greatly.

CORD has prepared a model curriculum for schools to consider in those instances where a two-year biotechnician program is desirable and feasible. The curriculum, outlined at the end of this paper, is somewhat tentative and speculative, as it should be at this point for an emerging technology. Nevertheless, it provides educators and local employers something to review and revise as they strive to serve their region's unique needs. The curriculum is based on the quarter system and averages 26 contact hours a week.

The model curriculum can be tailored easily to meet the needs of the various biotechnology applications. The courses marked with asterisks are all related to instrumentation and control, a line of study that should be pursued particularly by students who plan to work with fermentation technology. These courses might be replaced by courses in the microbiology of food spoilage, food preservation techniques and nutrition if the curriculum were geared more toward the food industry. In a region where agriculture dominates, courses in plant breeding, seed crop development, plant physiology and plant diseases might be substituted.

RECOMMENDATIONS FOR IMPLEMENTING A BIOTECHNOLOGY CURRICULUM

Results of this study suggest that two or three biotechnician programs could be successfully implemented in the early 1990s. These schools should be located in the northeastern United States and in California, since these are the major centers of the biotech industry. Other schools will be needed later in the decade.

It is recommended that a school interested in implementing a two-year biotechnician program do so in stages. The first step might be to add biotech courses to related curricula that is already in place--for example, medical technology, agriculture, horticulture, instrumentation and control, food technology, and chemical technology. Continuing education programs also might be implemented that upgrade and retrain the employees of local biotech companies. Then as the need for biotechnicians increases and industry recognizes the value of two-year programs, a full curriculum in biotechnology could be established upon the foundation that already has been laid.

For example, schools could add courses on the instrumentation and controls required by large-scale fermentation processes to its instrumentation curriculum. They could add courses on protein chemistry to the existing chemistry curriculum to prepare technicians to work in the area of recombinant DNA. To agriculture or horticulture programs, courses could be added on cloning and cell/tissue culture. The graduates from these options could find jobs in the many companies on the fringe of biotechnology--companies who primarily act as support groups for the biotech industry. When local need justifies a full biotechnician program, these courses can be integrated into a comprehensive curriculum.

CONSIDERATIONS

Schools that consider implementing biotechnician programs should be aware that the biotechnology industry in general holds some reservations about the ability of two-year schools to produce technicians who can compete with graduates from four-year schools. Industry representatives on the task force for this study, however, did note that future hiring plans are usually based on hiring practices that address current needs, not future needs. Since research and development work presently dominates the biotechnology industry, companies hire individuals who hold B.S. degrees as a minimum, and they tend to see that trend continuing. They do not yet clearly perceive that their technician needs will likely change when they enter full-scale production. Also, since biotechnology companies have had little or no experience in employing two-year technicians who have been trained specifically for biotechnology, they have little awareness of the potential value of such technicians. Two-year postsecondary schools interested in establishing biotechnician training programs must accept the challenge of "educating" the biotech industry.

Two-year schools should train technicians who can work as operators, instrumentation technicians and quality assurance and quality control technicians. These are the positions that will need to be filled when production begins to dominate the biotechnology industry, and these are the positions in which a two-year graduate can excel.

Biotechnology programs are expensive. Highly sophisticated laboratory setups are required because industry wants technicians who are experienced in the operation of state-of-the-art equipment. Also, quality instructors will demand high salaries.

Schools must be able to establish internships at local companies, for the biotech industry values experience almost as much as it does degrees. Also, faculty should be encouraged to return to industry on a regular basis so they can keep up with the many changes that are occurring in this rapidly evolving technology.

MODEL CURRICULUM FOR A TWO-YEAR
BIOTECHNICIAN TRAINING PROGRAM

Year One

Quarter 1
- Introduction to Biotechnology
- Technical Math I--Algebra/Geometry
- Chemistry I--Inorganic
- Molecular and Cell Biology I
- Technical Communications I

Quarter 2
- Technical Math II--Statistics/Precalculus
- *Applied Physics I
- Molecular and Cell Biology II
- Chemistry II--Organic
- Technical Communications II

Quarter 3
- Principles of Microbiology
- Biochemistry
- *Applied Physics II
- *Electronics
- *Elective

Year Two

Quarter 4
- Industrial Microbiology
- Computer Operations
- *Fundamentals of Instrumentation and Control
- Analytical Chemistry
- Fluid Power Devices

Quarter 5
- Applied Genetics
- Instrumental Analysis
- Economics in Technology
- Biotech Internship or Project
- *Mechanical Devices and Systems
- Elective

Quarter 6
- Protein Chemistry
- Industrial Instrumentation
- Industrial Relations
- Biotech Project or Internship
- Technical Elective

EVOLUTION OF A WORKFORCE FOR

AN EMERGING TECHNOLOGY

1. PERIOD OF DISCOVERY--SCIENTISTS

2. PERIOD OF DEVELOPMENT--SCIENTISTS/ENGINEERS

3. PERIOD OF APPLICATION--ENGINEERS/TECHNICIANS

4. PERIOD OF EXPLOITATION--ENGINEERS/TECHNICIANS/OPERATORS

AREAS OF BIOTECHNOLOGY INVOLVEMENT

	EAST	MIDDLE	WEST	ENTIRE USA
HUMAN HEALTH CARE	80%	61%	76%	74%
AGRICULTURE/ANIMAL HEALTH	60%	78%	44%	59%
ENERGY/ENVIRONMENT	28%	44%	24%	29%
FOOD	33%	39%	12%	28%

SURVEY DATA

242 - SURVEYS MAILED

86 - USABLE RESPONSES

36% - USABLE RESPONSE RATE

- SURVEY WAS MAILED TO COMPANIES INVOLVED IN HUMAN HEALTH, AGRICULTURE AND ANIMAL HEALTH, ENERGY AND ENVIRONMENT, AND FOOD.

- SURVEY DID NOT INCLUDE APPLICATIONS IN BIOMEDICAL EQUIPMENT OR PROSTHETICS.

Distribution of Biotech Companies Surveyed

SCIENTISTS AND TECHNICIANS WORKING

IN BIOTECHNOLOGY

	BIOTECHNOLOGY RESEARCH AND DEVELOPMENT	BIOTECHNOLOGY PRODUCTION
PROFESSIONAL SCIENTISTS	6205	1311
TECHNICIANS	6204	2239

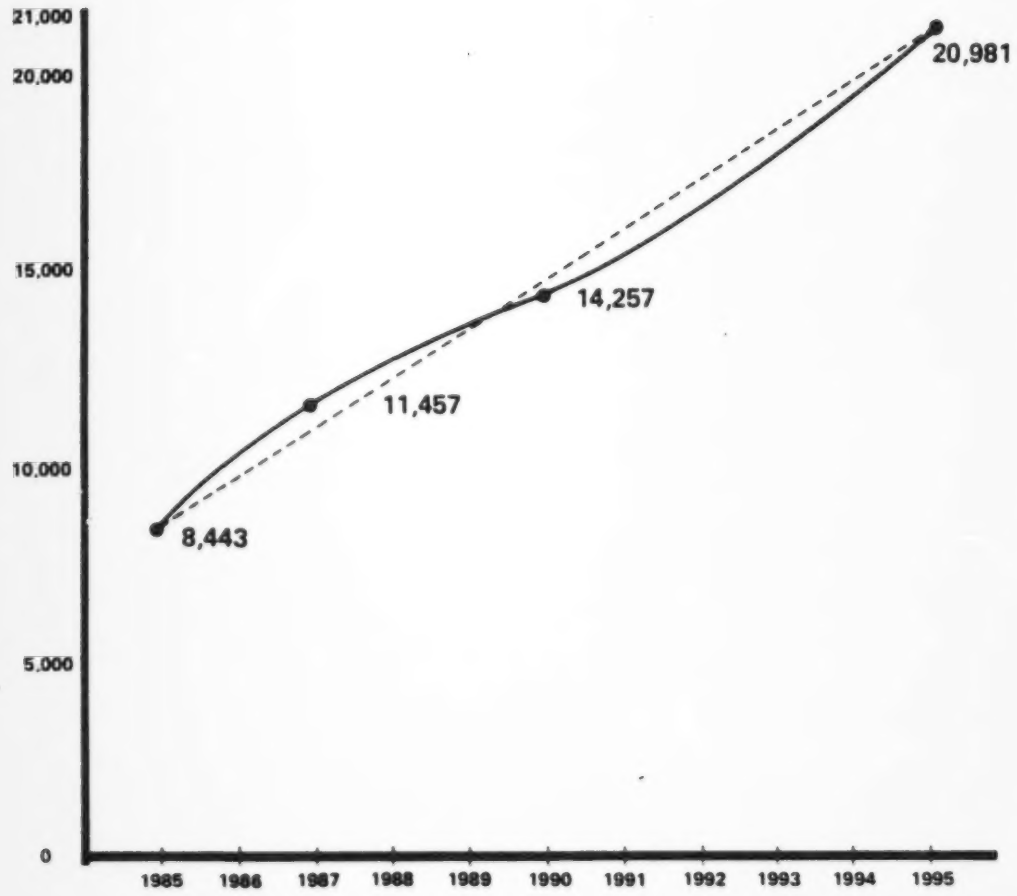
NEW BIOTECHNICIAN NEEDS

	BY 1987	BY 1990	BY 1995
TOTAL USA	3,014	5,814	12,538
EAST	2,165	3,069	7,362
MIDDLE	313	943	1,199
WEST	202	2,215	4,686

CUMULATIVE NEED FOR BIOTECHNICIANS

	1985	1987	1990	1995
USA*	8,443	11,457	14,257	20,981
EAST	2,928	5,093	5,997	10,290
MIDDLE	1,645	1,958	2,588	2,844
WEST	3,876	4,078	6,091	8,562

* TOTAL TECHNICIANS IN USA NOT EQUAL TO SUM OF TECHNICIANS IN EAST, WEST AND MIDDLE BECAUSE SEVERAL RESPONDENTS DID NOT INDICATE THEIR LOCATIONS.



Predicted Need for Biotechnicians

WHAT EDUCATION LEVEL DOES YOUR COMPANY EXPECT OF BIOTECHNICIANS?

HIGH SCHOOL	5%
AAS(2-YEAR)	16%
BS/BA	56%
MS/MA	19%
PHD	2%
NO RESPONSE	2%

IN FUTURE HIRING WOULD YOUR COMPANY CONSIDER TWO-YEAR POSTSECONDARY GRADUATES FROM A BIOTECHNOLOGY CURRICULUM?

YES	17%
MAYBE	38%
NO	43%
NO RESPONSE	2%

TWO-YEAR BIOTECHNOLOGY CURRICULUM

YEAR 1

QUARTER 1

INTRODUCTION TO BIOTECHNOLOGY
TECHNICAL MATH I - ALGEBRA/GEOMETRY
CHEMISTRY I - INORGANIC
MOLECULAR AND CELL BIOLOGY I
TECHNICAL COMMUNICATIONS I

QUARTER 2

TECHNICAL MATH II - STATISTICS/PRECALCULUS
* APPLIED PHYSICS I
MOLECULAR AND CELL BIOLOGY II
CHEMISTRY II - ORGANIC
TECHNICAL COMMUNICATIONS

QUARTER 3

PRINCIPLES OF MICROBIOLOGY
BIOCHEMISTRY
* APPLIED PHYSICS II
* ELECTRONICS
ELECTIVE

TWO-YEAR BIOTECHNOLOGY CURRICULUM

YEAR 2

QUARTER 4

INDUSTRIAL MICROBIOLOGY

COMPUTER OPERATIONS

* FUNDAMENTALS OF INSTRUMENTATION AND CONTROL

ANALYTICAL CHEMISTRY

* FLUID POWER DEVICES

QUARTER 5

APPLIED GENETICS

INSTRUMENTAL ANALYSIS

ECONOMICS IN TECHNOLOGY

BIOTECH INTERNSHIP OR PROJECT

* MECHANICAL DEVICES AND SYSTEMS

ELECTIVE

QUARTER 6

PROTEIN CHEMISTRY

INDUSTRIAL INSTRUMENTATION

INDUSTRIAL RELATIONS

BIOTECH PROJECT OR INTERNSHIP

TECHNICAL ELECTIVE

MOST BIOTECHNICIANS
WILL SPECIALIZE IN ONE
OF THREE AREAS

RECOMBINANT DNA

CELL/TISSUE CULTURE

FERMENTATION TECHNOLOGY

STEPS FOR IMPLEMENTING A BIOTECHNOLOGY PROGRAM

- DO LOCAL NEEDS ASSESSMENT
- WORK CLOSELY WITH LOCAL INDUSTRY TO ENSURE CURRICULUM WILL MEET THEIR NEEDS
- MOST SCHOOLS SHOULD START SLOWLY
  - ADD COURSES TO EXISTING CURRICULA SUCH AS:
    MEDICAL TECHNOLOGY
    AGRICULTURE
    HORTICULTURE
    INSTRUMENTATION AND CONTROL
    FOOD TECHNOLOGY
    CHEMICAL TECHNOLOGY
  - PROVIDE CONTINUING EDUCATION COURSES FOR EXISTING INDUSTRY EMPLOYEES
  - AS PROGRAMS BECOME ACCEPTED, PULL TOGETHER A TWO-YEAR CURRICULUM
- ESTABLISH INTERNSHIPS AT LOCAL BIOTECH COMPANIES FOR STUDENTS AND FACULTY

OTHER SUPPORT FROM TWO-YEAR POSTSECONDARY INSTITUTIONS

- IMPLEMENT INDIVIDUAL COURSES NEEDED BY LOCAL BIOTECH COMPANIES FOR THE CONTINUING EDUCATION OF THEIR EMPLOYEES

- ADD COURSES WITH BIOTECH EMPHASIS TO EXISTING RELATED CURRICULUM

- PROVIDE BIOTECHNOLOGY SURVEY COURSE AS PART OF THE CONTINUING EDUCATION PROGRAM OR AS ELECTIVES IN OTHER DEGREE PROGRAM TO INCREASE PUBLIC AWARENESS OF AND REDUCE NEGATIVE REACTION TO BIOTECHNOLOGY

- PROVIDE FACILITIES WHERE INDUSTRY COULD HOLD INDUSTRY SPONSORED WORKSHOPS AND SHORT COURSES

- PROVIDE CAREER GUIDANCE FOR STUDENTS WISHING TO ENTER FIELD OF BIOTECHNOLOGY